STADIA SURVEYING.

Written for Engineering News.

BY JAMES P. ALLEN, U. S. ASST. ENG., CHARLESTON, S. C.

The method of surveying in which distances are determined from the space covered on a rod by parallel wires in the transit is known to all engineers, although few, comparatively, have given it any attention.

The Coast Survey and the Lake Survey have both used it. It is also employed by the U. S. Engineer Corps in their surveys for the improvement of rivers and harbors. But its use in ordinary engineering fieldwork is limited.

The following notes are offered in advocacy of a broader field of usefulness for the stadia method:

We are concerned at present only with the practical portion of the subject. The following formulæ by Prof. S. W. Robinson embody all of the corrections, and give results which are theoretically accurate, or so nearly so that no error in practice can result from their use. The rod is supposed to be held vertically.

$$H = \frac{R'}{2R}(B - c - f)\ sin.\ 2V + (c + f)\ sin.\ V \quad (1)$$

$$D = \frac{R'}{R}(B - c - f)\ cos.^2 V + (c + f)\ cos.\ V \quad (2)$$

where

R' = any distance as read by the stadia.
B = the length of a measured base.
R = the reading of the stadia on that base.
V = the angle of elevation or depression.
c = the distance from center of object glass to center of instrument.
f = the principal focal length of the object glass.
H = the corrected height of the point sighted at above the axis of revolution of the telescope.
D = the horizontal distance of said point from center of instrument.

These formulæ may be placed under the following forms:

$$H = \frac{R'}{2R} B\ sin.\ 2V - (c+f)\ sin.\ V\left(\frac{R'}{R} cos.\ V - 1\right) (3).$$

$$D = \frac{R'}{R} B\ cos.^2 V - (c+f)\ cos.\ V\left(\frac{R'}{R} cos.\ V - 1\right) (4).$$

For a great deal of work, to which the stadia method is adapted, the whole of the later portion of these expressions may be neglected, giving the following abbreviated formulæ:

$$H = \frac{R'}{2R} B.\ sin.\ 2V, \text{ and } D = \frac{R'}{R} C\ cos.^2 V.$$

The value of $(c + f)$ varies for different instruments. It may be assumed to be 1.4 ft. The engineer can, however, readily determine it for himself by measuring the distance from the object glass, when focused upon a distant object, to the adjusting screws of the diaphragm, and the distance from the object glass to the center of the instrument. The first measurement gives the value of f, and the other that of c. Since R is generally made equal to B, the formulæ above reduce still further to

$$H = \frac{R'}{2} sin.\ 2V\ (5) \text{ and } D = R\ cos.^2 V\ (6).$$

It is possible to do fair work upon ordinarily level ground with any engineers' transit having stadia hairs introduced, but for general work it is imperative that the instrument have a vertical limb.

To put in the extra spider hairs necessary for stadia readings, the diaphragm must be taken out, and the hairs stretched on separately. Great care should be exercised in stretching the hairs all that they will bear, otherwise they will change in damp weather. A pair of spacing-dividers with a bit of wax on each point is useful for this purpose. It is recommended to breathe upon the hairs while stretching.

The hairs should be carefully spaced on the diaphragm so as to secure a convenient rod. It is best that the rod should have about 1 ft. for a distance 100 ft. Now, if X represent the distance from the optical center of the object glass to the stadia hairs, when the instrument is focused for 100 ft., we have

$$a \text{ (in feet)} : 100 \text{ ft.} :: x \text{ (in inches)} : 12$$

$$\therefore x = \frac{12a}{100} = 0.12 \times a = \text{space in inches}$$

between stadia wires on diaphragm.

It will be understood that we do not in this manner fix the graduation of the rod, which must be determined by careful experiment after the hairs are in.

The rod should be about 12 ft. long, of inch stuff well seasoned. For convenience of transportation it may be hinged in the middle, so that two parts of the face may fold inward. A short plumb-bob upon the back of the rod might contribute to accuracy, but it is not considered essential.

The design for the graduation of the rod is largely a matter of choice. Fig. 1, which is believed to have originated with the U. S. Survey of the Northern Lakes, is probably the best for general purposes. Fig. 2 shows a rod reading to feet, which, however, is only suited to short distances.

The ordinary method of determining the length of a 100-foot division on the rod is as follows:

A loose line of 1,000 ft. is measured very carefully on level ground. Over one extremity of this base the instrument is placed, and the rod is held at the other. By the use of temporary card-board targets the space covered by the stadia hairs is determined. This is sub-divided into ten parts. The pattern is penciled on by using a stencil, and the figures are afterwards painted black. B and R in the formulæ are thus made equal, and each is equal to 1,000 ft.

In the foregoing only the stadia transit with fixed wires has been considered. For many reasons an instrument with the wires adjustable is to

FIG. 1.

Fig. 3.

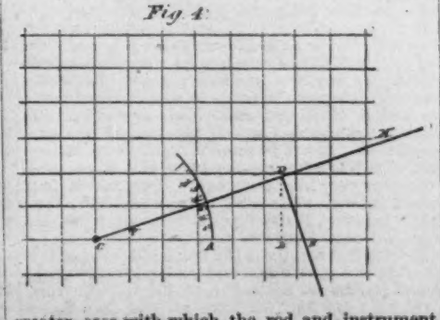
FIG. 2.

be preferred. In fact, the advantages of such an instrument greatly outweigh the disadvantages, largely imaginary, which are attributed to it.

The ordinary arrangement for making the adjustment is not a good one, and this may account for the prejudice against movable wires. The stadia hairs are not upon the diaphragm, but are carried, one each, upon two separate slides moved independently, each by a single screw. It is thought that this arrangement will lose its adjustment easily, and serious error may result. The writer has used an instrument in which one of the stadia wires is upon the main diaphragm and not movable separately, while the other is upon a diaphragm of its own, adjusted by loosening the upper or lower screw, as the case may require, and tightening that opposite. This instrument very rarely gets out of adjustment.

Of the advantages of an adjustable diaphragm, it is only necessary to mention at this point the

Fig. 4.



greater ease with which the rod and instrument are adapted to each other.

The rod is at once laid off with the desired figure, 1 ft. representing 100 and painted. Then, upon a measured base, the instrument is adjusted to it.

Should one of the hairs break, the engineer can himself put in another and adjust to the rod as at first. In the case of fixed wires the rod must be painted over, and graduated anew, or a troublesome correction applied to every stadia reading by a special scale or otherwise.

The simplest form to which our formulæ reduce (5) and (6), may not be considered sufficiently accurate for some classes of work.

Different plans have been suggested for obtaining more accurate results without making the computation by the formulæ (1) and (2).

In a book of tables by Alfred Noble and W. T. Casgrain, U. S. Assistant Engineers, published in 1871 by the Engineer Department of the Government, the correct distance and height are obtained as in a traverse table, for values of the vertical angle V to minutes.

These tables are based upon formulæ (1) and (2), the values of $(c+f)\ cos.\ V$ and $(c+f)\ sin.\ V$, appearing as additional corrections in separate columns. In another book of "Tables showing Difference of Level" "and for Horizontal Reductions," by J. A. Ockerson and Jared Teeple, assistant engineers, U. S. Lake Survey, heights are given for each 10 meters stadia reading; and, for the intermediate meters, the additional elevation is obtained from the common difference at the right of the page. This is Table I.

Table II. supplements Table I. giving the means of getting heights for greater readings than are given in Table I.

Table III. starts "to reduce reading on a slope to horizontal distances" for each degree and minute from 2° to 11°.

The following is the method suggested for graduating the rod in order to diminish the error due to $(c+f)$:

Measure a base, marking the 100, 200, 300, and 400 meter points. Set the transit over the zero point. Hold the rod at the first point marked, and determine the space covered by the wires (which are supposed to be fixed). This space is measured. Next hold at 200, determine the space on the rod, measure it as before, and so on for all points to the 400 meters. Then in the words of the book, "it is best to distribute $(c+f)$, which is small, among the several determined distances. Hence take for the length of each 100 meters space the mean of all the 100 meter spaces determined. That is to add together the length of the 100, 200, etc., spaces, and divide by the number of 100 spaces determined. A little more weight should perhaps be given to the short distances as the targets are more distinct."

It would seem as though this method was equivalent to graduating the rod upon a base shorter than 400 meters in the way already described for an instrument with fixed wires, the error due to $(c + f)$ still obtaining.

It will be observed, however, upon studying the formulæ, that this error is less the nearer the reading approaches the length of the measured base, and a short base may sometimes be better than a long one, if $(c + f)$ be neglected.

With adjustable wires it is possible to select a length of base, greater or less, as we may expect our readings to be greater or less. In other words, if a survey is to be made where the readings will be short, adjust upon a short base, and vice versa, selecting for the length of base, as nearly as may be, a mean of the expected readings. Since we can seldom predict either long or short distances exclusively, but may have both very long and very short, this plan does not recommend itself for general work.

The direct reading of the stadia rod for horizontal distances on level ground and formulæ (5) and (6) for measurements on slopes are generally close enough. The tables are not popular on account of the labor which they entail.

The following plan for graduating the rod almost obliterates the error in question, and does not materially increase the labor of working up the notes, over and above that which is essential to any application of this method.

We assume, as is ordinarily done, $B = R$, and suppose the length of our measured base B to be infinite. From the formulæ (3) and (4), we have

$$H = \frac{R'}{2} sin.\ 2V + (c + f)\ sin.\ V.$$

$$D = R'\ cos.^2 V + (c + f)\ cos.\ V.,$$

which we propose to write

$$H = \left(\frac{R' + (c + f)}{2}\right) sin.\ 2V\ (7), \text{ assuming } (c + f)\ sin.\ V = \frac{(c + f)\ sin.\ 2V}{2}$$

$$D = [R' + (c + f)]\ cos.^2 V\ (8);\ \text{assuming } (c + f)\ cos.\ V = (c + f)\ cos.^2 V.$$

Upon a level (8) becomes $D = R' + (c + f) = R' + 1.4$

$$\therefore R' = D - 1.4.$$

Suppose we then measure a base of 501.4 (rather than 1001.4, as giving a more distinct view of the rod). Make the instrument read 500 ft. exactly upon this base, as already described for adjustable wires or fixed, as the case may be. To each reading of the rod we have now to add 1.4 ft., a mental operation which can hardly be considered burdensome. We thus obtain the correct distance upon a level.

If the vertical angle be read, formulæ (7) and (8), which are equivalent to (5) and (6), should be used.

For some other value of $(c + f)$ than 1.4 ft., we will have to substitute this value for 1.4 in the process.

In describing the field work, although, as has been already said, some work can be done with an

ordinary transit, we prefer to assume the use of a good stadia transit. This should have a clear telescope of comparatively large magnifying power (a very important feature of a stadia transit). a long bubble under the telescope, and a vertical arc of 60°, graduated to read 30' in elevation and 30' in depression. The horizontal graduation should be adopted to measuring angles to the right or left from 0 to 180°, and should also be numbered from 0 to 360°. The stadia rod is supposed to be graduated 1 ft. to 100 ft., and is consequently a self-reading level rod.

The field party need not consist of more than two men, besides the observer, and often a single stadia man will be all that is required. Axemen and boatmen in addition will sometimes be demanded by economy and the necessity for rapid work.

In the surveying of rivers the stadia method is especially useful. The readings being mainly horizontal, no reduction of the notes by formulæ is necessary, if $(c + f)$ be neglected.

It is customary to run a chain line on one bank, or to triangulate, in order to obtain a base line for the survey. The stadia lines are closed upon points so fixed at convenient intervals. The method of carrying the azimuth is usually adopted, all angles referring to the true or magnetic meridian.

The topography of the banks and details are run in by taking bearings to points and stadia distances.

In carrying forward the line, clearing can be avoided where the width is not too great by crossing from side to side (see Fig. 3).

It will be seen that the economical working of the method will depend largely upon the judgment of the observer, and of the stadia run in the selection of points.

If it be desired to read a distance greater than that corresponding with the length of the rod, or if a portion only of the rod can be seen, the distance given by the upper wire and the center or original horizontal wire should be read, and then that of the center and the lower wires. The sum of these two readings will be the distance. Long distances, however, are undesirable. Sometimes it is required to survey a stream or a slough hastily, and compass bearings are sufficiently close. Let the transit at a Fig. 3 take the bearing by the north end of the needle and the stadia distance to *b*. Now set up at *c*, take the bearing by the south end of the needle and the stadia distance to *b*, and read the north end of the needle and the distance to *d*. One rodman can be kept upon each bank, and only occasionally will the observer need to cross. The field notes are written as though the instrument had been set at every point. It is to facilitate this that the south end of the needle is recommended to be read from *c* to *b*. Intermediate readings are taken to give the shore line, sounding stakes and all the details. But for the space required we could multiply the uses of the stadia instrument in hydrographical surveying.

For contour lines and the topography of hillsides, different plans suggest themselves. A number of points may be located, and their heights determined, at each setting of the instrument, by reading the vertical angle as well as the bearing and distance, and the contours sketched by the eye upon the field sketch; or cross-sections may be made at suitable points, perhaps several at a setting, or a combination of both of these plans. The line of collimation of the telescope should always be directed upon the same point of the rod for obtaining the vertical angle. If considerable accuracy is desired, the levels can be carried forward by the use of the bubble under the telescope, which should be carefully adjusted by the two-peg method. The stadia rod serves as a level rod.

For irrigating ditches or pipe lines very excellent and economical preliminary surveys can be made with the stadia, the alignment, levels and topography being obtained with a single instrument and a small party. If compass bearings will answer, it is only necessary to set at every other angle.

With the vertical arc or the bubble it is easy to fit any grade to the ground.

The writer once had occasion to run a trial line for an irrigating ditch of 1½ miles. It was done with the stadia and a single man in about four hours. Running over the ground afterward with transit and level, the location differed very slightly from the preliminary line, and the levels checked within a few tenths.

We touch upon the subject of surveys for railroads by the stadia with some hesitation, not because we have any doubt as to the utility of the method, but because our experience in railroad work is limited. Hoping that this admission will serve as an apology for possible blunders, we unhesitatingly recommend stadia surveying for the preliminary line, including topography, and for trial lines.

The party may consist of an assistant engineer, an instrument man, three stadia men and three axemen.

The assistant engineer takes general direction of the work, and does the sketching. The instrument man reads the angles and stadia distances, takes the levels, and keeps all of the notes of his own work.

Each stadia man has his axeman. In some country a brush hook is an excellent substitute for an axe. One stadia man gives elevations along the line as designated by the assistant engineer, taking points wherever they may be required for an accurate profile. Another stadia man gives cross-sections at proper intervals, by holding the rod at a succession of points on a line, as nearly as may be perpendicular to the line of the survey. The third takes up houses, fences and other details for topography. Often the third stadia is superfluous. No. 1 can do his work, and two rods will generally keep the observer busy. No 2 works on the back course, so that he can give back sight for both transit and level work. No 1 gives the foresights. The observer reads both the angle and distance to the new station. The latter he can check when he sights back upon No. 2.

It will hardly be necessary to remind the reader that the stadia rod is supposed to be a self reading level rod, and that the bubble under the telescope enables us to take fairly accurate levels. The reading of the vertical angle will enable us to determine the heights of points which are too far above or below the level line at any setting to be determined in the ordinary manner of leveling.

When No. 1 reaches the proper point, as determined from the length of the B. S., by a signal, the observer directs a turning point to be put in, which is done by the axeman, who also marks its position with a tall stake. When No. 2 reaches this, he holds upon it, the instrument being now at the next station, and the B. S. is read—also the distance. The observer has it in his power generally to secure equal sights. Otherwise long sights must be corrected for curvature and refraction.

The following form of field notes is suited to this class of work:

FOR LEFT HAND PAGE.

Sta. or point sighted at.	At Sta. Bearing (or Angle).		Distance, as read.	Vertical angle.	Remarks.
	Ver. A. (or Rt.)	Ver. B. (or Lt.)			

The stations, or points where the transit is set up, can be distinguished by the prefixing of a symbol or the abbreviation "Sta." from the points whose position and elevation alone we wish to obtain. The "Stas." should be numbered consecutively, and the points may run 1, 2, 3, etc., for each "Sta." without other designation.

With the method of carrying the azimuth both veniers are read. The engineer may prefer to read angles to the rt. and lt., however. The record for either case can be made as indicated. The distance is the reading of the stadia; any corrections to be applied afterward. Angles of elevation and depression may be distinguished by prefixing + or — sign. In the column "Remarks," the point sighted at should be described briefly, as, for example, "Fence corner," "N. W. corner house," "center wagon road," "for contours," etc.

Upon the right-hand page we would have level notes in the ordinary form, keeping the F. S. and B. S. upon the same line as that which the bearing and distance of the point occupy on the left-hand page.

If there be a great many points required, the instrument man should have a recorder.

Two serious difficulties present themselves.

If the ground be very densely wooded or covered with underbrush, it is difficult to read the rod. But the same difficulty exists to a greater or less extent in carrying any line over such ground. The stadia line can sometimes be made to pass through vistas or partial clearings, and offsets made into the thicket, toward and across the line of the proposed road. It will be remembered in this connection that it is not necessary to see the whole rod, except for very long distances. Two and a half feet of the rod will enable us to read 500 ft. very nearly (exactly, if the upper and lower wires are equally distant from the center wire).

The other difficulty is the increased labor of calculating the excavation and embankment where the elevations are not taken at 100 ft. intervals. To this we say that we have all the data for a fairly accurate profile, and, if this be properly prepared, we cannot see why, for preliminary work, the cuts and fills may not be taken from it directly and the cross stations from the contours. The advantages are these. The work is all under the eye of the assistant engineer and is accomplished at one operation. The party is only about one-half as large, and we believe that with a little practice the survey can be pushed quite as rapidly as by the ordinary method. The problems of avoiding obstacles, crossing streams, etc., are greatly simplified. For reducing that portion of the notes of any stadia survey, where the vertical angle has been read the tables mentioned may be used if they can be obtained, or the corrected distance and height can be calculated by the formulæ.

The following is a very convenient graphical construction for formulæ (5) and (6), or (7) and (8):

A piece of cross-section paper is smoothly stretched upon a board. Let each division represent single feet or 10 ft. or 100 ft., as convenient. Then from a center *c*, at one of the principal divisions, describe a large arc, *A*, Fig. 4, and lay it off into degrees, half degrees and quarter degrees. Upon a piece of tracing vellum lay off two straight lines at right angles. The cloth should be large enough to admit of a length, *C D*, equal to the maximum stadia reading, and *D M* equal to the radius of the arc, *A*.

Now place the tracing cloth over the cross section paper, keeping *C*, the center of the arc, on the line *CM*; and, using the graduated arc *A*, make the angle $MCB = V$. Slip the cloth to the right or left along the line *CM* until $CB = R$. Then $CE = D$ and $DE = H$, which are read off directly on the profile paper. For

$CB = R'$, and we have $R' \cos. V = CD$.

$CE = CD \cos. V = R' \cos.^2 V = D$.

Also

$$R' \sin. V = DB.$$

$$DE = DB \cos. V = R' \sin. V \cos. V = \frac{R'}{2} \sin. 2V = H.$$

A straight-edge and triangle may be used instead of the vellum.

For formulæ (7) and (8) the value of $(c + f)$ must be added before using the diagram.

The degree of accuracy attainable with the stadia depends largely upon the care with which the adjustments are made, and upon the manner in which the work is done. By the Lake Survey we have understood that a discrepancy not exceeding 1 in 400 for the horizontal measurement was admitted, while an average error of only 1 in 600 was the exhibit of some of the parties.

Either is close enough for most work to which the method is adapted, and we know by experience that with reasonable care and precaution the best result (1 in 600) can be attained.

The basis of comparison is supposed to be a chained line, which is itself liable to error. We do not believe that stadia surveying is applicable where exact work is demanded, although great accuracy is often claimed for it. In very rough country it is doubtless more accurate than ordinary chaining, but it would seem best to assign it to that which should be its province, viz.: approximate surveying, including preliminary surveys and examinations and the filling in of details. For such work there is no better method, offering as it does a close approximation, secured with cheapness and rapidity.

CORRESPONDENCE.

CORRECTION.

NEW YORK, Jan. 28, 1882.

EDITOR ENGINEERING NEWS:

In the article "The Metric System for Railroads," page 28, please correct an error in the last cross-section of the *field notes*. Station 26 should be station 25 + 26; + 26 meaning the $\frac{26}{100}$ of a chain. Respectfully, J. W.

METRIC PROFILE PAPER.

NEW YORK, Jan. 27, 1882.

EDITOR ENGINEERING NEWS:

In your issue of Jan. 7, in a very interesting letter from Mr. Emile Low on the metric system on the Mexican railways, he says: "For profiles thus far the usual profile paper is being used, plate *B*, no paper ruled to metric values being obtainable."

As the New York agent for J. W. Queen & Co., I would respectfully state to those engineers interested, that in addition to their regular continuous profile paper, *A* and *B*, they have been making since March, 1881, a continuous profile paper in metric values. The divisions are, both vertical and horizontal lines, five to each half centimeter, with every fifth line heavy; every tenth-half centimeter is also indicated by an extra heavy line. This ruling makes a large square, having sides of five centimeters, sub-divided into squares of half centimeters, which are again divided by faint lines into small squares of one-fifth of a half centimeter. Respectfully,

G. S. WOOLMAN.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SO.C C. E.

Continued from page 33.

CLXXXIII.—GREENFIELD.

Greenfield, Massachusetts, in lat. 42° 30' N., long. 73° W., is on rolling land a mile distant from and 100 ft. above the Connecticut River.

The town was settled in 1738 and incorporated in 1753. Water-works were built in 1870 by the "Fire District," after the plans of A. R. Field and under the direction of a construction committee.

The supply is taken from an impounding reservoir formed by a stone dam 60 ft. long, 85 ft. high,

16 ft. thick at bottom and 10 ft. at top, which floods an area of 4 acres and receives the drainage of 8 square miles of mountainous country.

The capacity of the reservoir is 10,000,000 gallons, and its surface is 235 ft. above the village, to which the water is conveyed 5 miles in cast-iron pipes of 8-in. and 6-in. diameter. There are 7 miles of distributing pipes of 4-in. and 3-in. diameter, with 40 fire hydrants, 21 gates, 600 taps and 2 meters. Service pipes are of galvanized iron.

The population in 1880 was 3,903, and the daily consumption 90,000 gallons.

The works cost $120,000. The receipts have been $60,000. There is a bonded debt of $60,000 bearing 5 per cent. interest. The receipts in 1880 were $5,274.51, and the expenses, exclusive of interest, $1,530.06.

The works are managed by three water commissioners, one of whom is the superintendent. This position is now held by A. A. Rankin.

CLXXXIV.—CHICOPEE.

Chicopee, Massachusetts, in lat. 42° 9′ N., long. 72° 37′ W., is on the south bank of the Chicopee River at its junction with the Connecticut River, 3 miles N. W. of Springfield. The town is on a nearly level plateau of irregular outline and the slopes which rise gradually from it to a more elevated sandy plain, the water falling on which feeds springs, the water of which was collected and carried in pipes to supply the town in 1845, after plans of Stockwell Bettes, of Springfield.

The town was settled in 1636, and was separately incorporated in 1848.

The present water-works were built in 1877 by a private company, taking the supply from an impounding reservoir on a brook north of the town, which is fed by springs issuing from the abovementioned sandy plain. The reservoir covers 3½ acres, and contains 5,250,000 gallons, the water having an average depth of 6 ft. The dam is 150 ft. long, 12 ft. high and 8 ft. wide on top, with earth slopes of 2½ to 1 on the water side and 1½ to 1 on the lower side. In the centre is a brick wall laid in cement and resting on a bed of quicksand confined by two rows of 6-in. sheet piling driven 12 ft. below the base of the dam. The water surface is from 20 to 80 ft. above the town.

The water is conveyed from the reservoir to the distribution pipes by an 8-in. wrought-iron cement-lined pipe, 8,300 ft. long. At half a mile from the terminus of this conduit, a pipe from a pump driven by a turbine wheel is connected with the distribution, and enables direct pressure to be applied for fire purposes. A check valve prevents back-flow into the reservoir.

Distribution is by cast-iron pipe for the most part. Some vitrified stoneware pipe has been used. There are 12 miles of pipe in use, with 29 fire hydrants, 10 fire reservoirs and 675 taps. The town furnishes hydrants and pays $500 per annum for the use of the water. Lead service pipe is used.

The population in 1880 was about 7,000. The consumption is not given.

The capital stock of the company is $50,000, the works have cost altogether $63,369.36, and the gross receipts to October, 1881, were $23,645.68. The receipts in 1880 were $5,843.02, and the expenses $789.26.

W. C. McClannan is President and E. R. Stickney Clerk of the Chicopee Water Company.

CLXXXV.—FITCHBURG.

Fitchburg, Massachusetts, in lat. 42° 34′ N., long. 71° 48′ W., is on the Nashua River, in a long, narrow valley, from which the ground rises on each side to a height of 350 ft. It was incorporated as a town in 1764 and as a city in 1872.

In 1871-2, water-works were built by the city, after plans of Phineas Ball, C. E., and under the superintendence of G. Raymond and W. A. Smith, taking the supply from Scott Brook, which drains a water shed of about one square mile. The natural flow of the stream was at first taken, and in 1876-7 an impounding resevoir covering 36 acres and containing 109,000,000 gallons was formed by building an earth dam 46 ft. high, with a heart wall of rubble masonry laid in cement. Two cast-iron pipes are laid through the dam, one on the natural surface, the other 16 ft above it, resting on stone piers. The dam was raised and strengthened in 1880, increasing the reservoir capacity to 2,000,000 gallons. From the dam a 24-in circular brick conduit conveys the water 7,916 ft. to Overlook reservoir, formed by building two dams across a ravine. The upper dam, 22 ft. high and 1,000 ft. long, has no openings.

The lower dam, 42 ft. high and 400 ft. long, with a heart wall of stone 2 ft. thick, is perforated by 2 outlet pipes of 12-in. and one of 16-in. diameter. Overlook reservoir included between these dams is 400 ft. above the city, covers 13 acres and contains 60,000 gallons.

In 1879 the brick conduit between the reservoirs was found to be greatly obstructed by fine roots which had penetrated the brick-work from adjacent trees, and grown in masses from 3 to 8 in. thick.

In 1874 a 14-in. wrought-iron and cement pipe was laid from the conduit near Scott Brook to Shattuck Brook, 8,300 ft. distant, and taking the water from a drainage area of 1¼ square miles. The brook was diverted by a small dam of sheet piling covered with earth.

From Overlook reservoir the water is distributed to the higher portions of the city.

At a point in the ravine 1,150 ft. distant from the lower overlook dam another dam, 21 ft. high, forms the Marshall reservoir, covering half an acre, and containing 1,000,000 gallons at 200 ft. above the lower part of the city, which it supplies.

The pressure in the city is 80 lbs. from the low-service and 155 lbs. from the high-service reservoir. The high-service pressure can be put on the low-service system when needed.

During the drought of 1880 a pipe was laid from the reservoir to Snow's Millpond to obtain additional water.

Distribution was at first by wrought-iron and cement pipe. Since 1876 cast-iron pipe has been used for extensions.

In 1875 about 2,500 ft. of street pipes were frozen solid. Several sections of 250 ft. in length were thawed out by injecting steam and hot water.

On June 6, 1877, lightning struck the pipes in two places, entirely ruining 2 000 ft. in length. In 1878 the pipes were again struck by lightning and injured. In both instances the damaged pipe was replaced by cast-iron mains.

The total length of pipe laid to Dec. 31, 1881, was 26 miles, with 203 fire hydrants, 198 gates and 1,255 taps; 93 meters are in use.

Service-pipes are of wrought iron, cement-lined. The population in 1880 was 12,405 and the daily consumption about 1,500,000 gallons. The works have cost $439,500. Interest on $400,000 6 per cent. bonds is paid out of taxation. The revenues of the works have paid the expenses of maintenance and supplied $78,071.31 to a sinking fund. The expenses in 1880 were $5,713.15 and the receipts $15,640.53.

The works are managed by a board of commissioners. Thomas C. Lovell is the Superintendent.

CLXXXVI.—BATAVIA.

Batavia, New York, in lat. 43° N., long. 78° 48′ W., is on Tonawanda Creek in a slightly undulating country. The town was settled in 1803.

Water-works were built in 1865 for the supply of the village, for fire protection and street sprinkling, taking water from Tonawanda Creek. The village erected two Holly pumps in the mill of J. G. Cameron and laid mains and put up hydrants in the streets. The mill owner furnished water, kept the machinery in order and ran it for a stipulated sum, and has the privilege of tapping the pipes and selling water for private purposes.

In 1873 Mr. Cameron put in two La France pumps. In 1878 Olmsted & McDonald, then the proprietors, put in a Knowles pump in addition, and in 1881 erected a wooden tank holding about 22,000 gallons, on a stone foundation, 40 ft. high, in the village. This tank is an equalizer of pressure. In case of fire the tank connection is closed and water pumped directly into the mains under 100 lbs. pressure. There are about five miles of cast-iron distribution pipe from 8-in. to 5-in. diameter, with 43 fire hydrants and 250 taps. The town pays D. A. McDonald, the present mill owner, $1,000 per year for furnishing water for street sprinkling and fire extinguishing. The cost of the works is not known and the operator's expenses and outside revenue are not stated.

The population in 1880 was 7,356.

CLXXXVII.—SEDALIA.

Sedalia, Missouri, in lat. 38° N., long. 94° W., is on a high, rolling prairie. A stream draining about 250 miles of prairie land has its rise 25 miles north of the town and flows past it. The town was settled in 1860, and incorporated as a city in 1864.

In 1871, water-works were built by the city, taking the supply from the creek and pumping it directly into the mains by a gang of 6 Holly upright 12-in. pumps, with 2 rotary pumps for fire pressure, operated by a Holly steam engine.

A large spring on the bank of the creek, about two miles, supplies 200,000 gallons daily. There is now in course of construction a dam 160 ft. long across the stream, with 2 openings in it, of 40 ft. each, fitted with 9 trap gates, which are to be dropped during floods, but closed in ordinary stages, thus creating a storage reservoir of about 40,000,000 million gallons capacity.

The highest part of the city is 153 ft. above the pumps, and at that point a wooden tank 40 ft. in diameter and 20 ft. high has been erected on a trestle 40 ft. high.

The ordinary pressure at the pumps is 85 lbs., and the fire pressure is sometimes 140 lbs. per square inch.

Distribution is by cast-iron pipe of from 12 to 4-in. diameter. Eight miles are in use, with 38 fire hydrants and 575 taps. Four meters are in use, but are reported as not working satisfactorily. Wrought-iron service pipes are used.

The population in 1880 was 9,561 and the daily consumption 500,000 gallons.

The works have cost $135,000. The bonded debt is $125,000, bearing interest at 5 per cent. The interest on the debt and an annual charge of $10 for each fire hydrant are paid from a general tax. The expenses of maintenance in 1880 were $9,000 and the receipts $9,445. The Council Committee on water-works manage the works. Louis Kumm is Chairman.

CLXXXVII.—WARSAW.

Warsaw, New York, in lat. 42° 45′ N., long. 78° 10′ W., is on O-at-ka Creek at the head of the valley of the same name, between two lofty ranges of hills, 1,013 ft. above sea level.

Settled in 1803, it was incorporated as a village in 1847. Water-works were built in 1870. Water-works were built in 1870 by a private company after the plans of James O. McClure, C. E., taking the supply from 9 springs on the hill east of the village and one large spring on the west hill. Two reservoirs on the east hill contain 500,000 gallons at 265 ft. above the town. These springs have never failed entirely, but the supply at times is small. The west hill spring, which is constant, supplies a reservoir holding 250,000 gallons 360 ft. above the town. The east and west reservoirs are connected by pipes.

Distribution is by cast-iron pipe, of which 6 miles are laid of from 8-in. to 3-in. diameter, with 30 fire hydrants, 10 gates and 260 taps. The town pays $1,000 a year for the use of the fire hydrants. The population in 1880 was 3,755 and the daily consumption 20,000 gallons.

The works have cost $30,000 and the total receipts have been $17,500. There is no bonded debt. The expenses in 1880 were $150 and the receipts $2,200. The capital stock of the company is $25,000. W. J. Humphrey is President; B. F. Fargo, Secretary and Treasurer, and J. O. McClure the Engineer.

CLXXXIX.—URBANA.

Urbana, Ohio, in lat. 42° 2′ N., long. 84° 53′ W., is in a rolling country, well supplied with springs. A small stream, fed by a spring, flows through the town, which is on nearly level ground, with a gravel subsoil, containing water at from 10 to 30 ft. below the surface.

Settled in 1792, it was incorporated as a city in 1867. In 1878 water-works were built for a private company by the Holly Manufacturing Co., taking the supply from a well 20 ft. in diameter and 15 ft. deep, and pumping directly into the mains by a Holly four-cylinder engine of 1½ million gallons' capacity, working under an ordinary pressure of 40 lbs. per square inch and a fire pressure of 100 lbs. Distribution is by cast-iron pipe, of which 9 miles are in use, of from 14 to 4-in. diameter, with 74 fire hydrants and 320 taps and 2 meters. Lead service pipe is used. The city pays $100 per year for each of 60 hydrants and $75 for each one over that number.

The population in 1880 was 6,252 and the daily consumption 250,000 gallons.

The capital stock of the company is $100,000 and the bonded debt $65,000, bearing 6 per cent. The works have cost $85,000. The expenses in 1880 were $3,400 and the receipts $10,050.

J. H. Ayers, M. D., is the Treasurer and Superintendent of the company.

(TO BE CONTINUED.)

The receipt of statistics as follows is acknowledged with thanks: From Louis Kumm, Chairman Committee on Water-works, statistics of the water-works of Sedalia, Mo. From Robert Surtees, City Engineer, report of water-works of Ottawa, Canada, December, 1881. From N. I. Jordan, Treasurer Water Company, statistics and water rates of the water-works of Auburn, Me. From Charles E. Fowler, City Engineer, contract between Water Company and City of New Haven, Dec. 15, 1881. From D. Hammond, Superintendent, statistics and water rates of the water-works of Emporia, Kan. From John M. Steele, Superintendent, statistics of water-works of Bordentown, N. J. From W. H. Johnson, Secretary, statistics and water rates of the water-works of Alpena, Mich., and laws under which the Water Company is organized. From A. W. Berry, Superintendent, statistics and water rates of the water-works of Gloversville, N. Y., and reports for years ending April 30, 1880 and 1881. From J. H. Ayers, M. D., Superintendent and Treasurer, statistics and water rates of the water-works of Urbana, O. From E. Metsch, Clerk and Superintendent, statistics of water-works of East Liverpool, O. From T. N. Boutelle, Superintendent, a description of the water-works, Fort Dodge, Iowa.

NO FLAGMAN WAS SENT BACK.—ROCHESTER, N. Y., Jan. 24.—This morning an east bound freight train on the New York Central Railway became stalled two miles east of Clyde, and a few minutes later the train following ran into it, smashing the caboose and setting fire to it. The flames were extinguished before the fire communicated to the other cars, and then it was discovered that Conductor John McManus, of the stalled train, was in the caboose and burned to death. The loss of property is inconsiderable, and the tracks were clear in an hour. It seems that no flagman went back from the stalled train.

ENGINEERING NEWS.

GEO. H. FROST.....PROPRIETOR.

Tribune Building, New York City.

JULIUS W. ADAMS, *Past President A. S. C. E.*, EDITOR.

S. D. V. BURR..... .....ASSOCIATE EDITOR.

SATURDAY, FEB. 4, 1882.

EDITORIAL ANNOUNCEMENTS.

Terms of Subscription.—To the United States and Canada, $4 per annum, including postage; all parts of Europe, $5, payable in advance. Remittances at the risk of the subscriber, unless made by registered letter or by draft, check or P. O. order, payable to GEO. H. FROST.

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Articles for Publication in the current number should be received at the office of publication not later than Thursday morning, and advertisements not later than Friday noon.

Correspondence upon subjects which naturally belongs to the province of this journal is solicited.

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SPUYTEN DUYVIL CATASTROPHE.

In last week's issue of ENGINEERING NEWS we published the verdict of the Coroner's jury in the case of the Spuyten Duyvil catastrophe, and at the same time republished opinions from the local press commenting upon the character of this verdict, a course which we have not hitherto pursued in such cases, but which we thought was called for, as exhibiting so fully the tendency of the framers, as well as the exponents of popular opinion, to diversity of sentiment, even upon matters which would appear to admit of but small differences of opinion, whether, as in the present case, we consider the simplicity and the concurrence of the evidence submitted to the jury, their sworn duty in the premises, or the great importance to obvious public interests, that "their trumpet should make no uncertain sound," and that no scapegoat should be found upon whom to visit the dereliction of duty on the part of any man or set of men who trifle with the lives of the traveling public. There has been too much of this disposition shown heretofore on the part of coroners' juries to evade their responsibilities and regard as *accidental*, and so beyond the control of man, what, in some cases, and notably in the present one, would have been miraculous had it not happened; and that the jury should have rendered, what the world characterizes as "so sweeping a verdict," in the very face of the Railroad King is an evidence of moral courage which should command the support of all, and which we most heartily approve.

Discussions upon the management of railroads have formed no part of our editorial labors. This field has been filled, and ably filled, by our valued contemporary, the *Railroad Gazette*, and to which we have been accustomed to look for practical and sound opinions upon all matters touching the management of roads, which in the present day is no longer regarded as a branch of engineering. It has reached us, however, that our failure to comment upon this late evidence of mismanagement is misunderstood, and we are, therefore, constrained to depart so far from the path which we had marked out for ourselves as to comment upon coroners' verdicts, and "give a reason for the faith which is in us," premising that while we make no claim to being "experts" in railroad management, yet we are not without experience in such matters, acquired in the days when the charge of railroads by their engineers did not cease on the completion of the work of construction. It is true, that the great complications growing out of various and diverse interests to be reconciled in order to the successful working of the railroad system of to-day, did not then exist, and the "bulls" and the "bears" were not permitted to thrust hoof or paw into affairs presumed to be beyond their capacity, but the principles and practices then found essential to successful operation are no whit less important now than then, being based upon the immutable laws of nature—and we may add—common sense.

As we understand the duty of a coroner's jury, and as expressed by one of the dailies, which was not in accord with the verdict rendered, it is to determine "where the responsibility rests for the loss of life."

The only feature in the case which will bear the characterization of "accident" was in the operation of releasing the air-brakes. This was performed by some one as a stupid joke. It does not appear in the evidence who this was, but it matters little, as in itself it was a small matter, not necessarily attended with any risk of what is called an "accident."

The train being stopped, the first duty of the conductor is to dispatch a brakeman with a signal, in each direction ordinarily, but in the present case, as it was known that a local train was following the express, the *first* duty of the conductor was to flag this train; the conductor failed to do this, or rather failed to see that it was done, and so became responsible for what happened. The rear brakeman knew that it was in the line of his duty to flag the coming train; had he performed his duty in this respect no loss of life would have occurred. This failure of duty on his part rendered him equally responsible with the conductor for what followed. The enginemen of the Chicago express, aware of the fact that the air-brake had been sprung, and it proving no part of their duty to investigate as to who had sprung the brakes, violated their known duty in attempting to move the train, and succeeding in moving the train to a point of absolute danger in reference to the field of observation from a following train became equally responsible with the conductor and brakemen for what subsequently happened. The engineman of the following train (Tarrytown local) aware by his time that there was a train in advance of him, and also aware of the principle that in approaching a dangerous point of the road he was not to rely wholly upon others to apprise him of danger, but should himself be keenly alive to the possibility of danger in his front, failed to exercise the proper degree of watchfulness, and rendered himself equally responsible with the conductor, brakeman and engineman of the express for what followed from his neglect. There are few places on the railroads leading out of New York where the element of *possible* danger, through neglect of employés to faithfully perform their duty, is more apparent than at this locality; and this *possibility* of danger should have been impressed upon the operatives of the road in the instructions from the Superintendent, calling their especial attention to the proper precautionary measures to be observed in passing it. The failure of the Superintendent in appreciating, or in causing his employés to appreciate, the fact that this was to be regarded as a point of danger, renders him responsible with them for what followed from their neglect or ignorance.

And finally, the economy which forbids the employment of a local flagman for this point of danger, and in the failure to supply obviously needed implements for such a catastrophe, as similar occurrences in our country have shown to be essential to save life, renders the managing head of this great road equally responsible with his employés. That this is so is evident if we consider that the concurrent action, or non-action, as the case may be of the *entire five* operatives, together with the defects in the regulations and the parsimony of the *owner*, was essential to bringing about that condition of things which resulted in *loss of life*. The mere stoppage of the train (a constant occurrence on railroads,) was not in itself a cause for the disaster which followed, but merely the *occasion*, through which the shortcomings of the agents of the road all conspired to bring about the fatal result.

We regard the verdict of the Coroner's Jury as eminently proper, and if the action of the Grand Jury should fail to confirm it, it will be more to be deplored than was the "accident" itself. [As we go to press we understand the action of the Grand Jury to be an indictment of the conductor and brakeman of the express "for negligence in the performance of their duty;" with a gentle reminder to the railroad company that it would be well if the trains carried certain tools, etc.

We have but a single remark to make to this:

Would the negligence of these two men alone have sufficed to insure a loss of life had the remaining individuals implicated by the Coroner's verdict performed their entire duty in the premises?]

COLORADO INSTITUTE OF ENGINEERS.

This new professional association has just been formed at Leadville, Col., and we have been favored with a series of circulars from the Committee on Organization. These circulars are for the instruction of candidates for membership, and are almost *verbatim* reprints from similar ones of the American Society of Civil Engineers. The membership is divided into resident and non-resident members and associates; the fees are for entrance $20, $15, $12 and $8 respectively, and quarterly dues are $6 and $1.50, the total being only a dollar or so less than for the New York Society. The new Association has apparently resolved to spend no time in discussing constitutions and by-laws, but presuming on the perfection of that of the A. S. C. E., adopts it bodily. Living in high altitudes, we judge from the aspirations of this latest fledgling, begets equally altitudinous ideas, and we are pleased to see that there is "nothing mean" about the new "Institute" in the way of asking a good price for admission to its sacred circle. The committee are Fred. G. Buckley, Thos. W. Jaycox and Chas. J. Moore, the two latter gentlemen being personally well known to us as enthusiastic and capable engineers, whom we trust will succeed in effecting a large and influential professional organization from among the many well qualified engineers in the far West. We think, however, they have made a mistake in modeling their organization after that of the A. S. C. E. instead of that of the American Institute of Mining Engineers. The committee's circular closes with stating that they believe engineers will "find profit in a membership"; we will await the advent of the Proceedings and Transactions of the new "Institute" to prove the faith that is in its promoters.

A DISASTROUS FIRE.

As we looked up casually from our work on Tuesday morning last the violent gesticulations of a rapidly-gathering crowd in the street just below drew our attention and another glance revealed a broad column of flame issuing from the old *World* newspaper building directly in front. Hastening to the street we were in time to witness the fearful leap of a woman from the top story to the hard pavement below, to meet death in another form than by fire, and to witness the heroic and successful feats performed in the saving of life by the fire department and citizens. For a time, during which moments seemed hours, one's heart seemed to cease beating while witnessing the fearful scramble for life by the flame-pursued occupants of the wretched trap that was burning, and only when the flames bursting from every opening cut off further efforts to save life could we realize the fierce contest that was in progress. Never before did we so realize the value of a minute of time as when witnessing the slow raising of a ladder to find it only too short to reach the point at which the fire-beleaguered supplicant awaited its coming as the only hope of life. The daily papers have spread far and wide every particular of this most disastrous fire; and but for its close proximity to our own quarters we would hardly have referred to it. The scenes transpiring before our windows since Tuesday must be seen to be appreciated, and while we write (Friday noon) a steamer is still puffing away at the mild-faced Ben Franklin, who scarcely could have dreamed of such sights as he has so imperturbably witnessed from his pedestal nearly all the week. Where was the busiest hive of newspaper workers in the city at the opening of the week, now only remains a huge pile of smoking débris, from which burnt safes are being hauled and around which a crowd is gathered in expectancy of seeing the possible remains of the burned victims exhumed. We can but record our opinion that the existence of such fire-traps is disgraceful to modern civilization, but we hardly expect to see much improvement so long as a ready market at enormous prices can be found for every foot of renting space. The efficiency of the modern fire department is never realized except on such an occasion, and its coolness, energy, fearlessness and promptness were never better exhibited than on this appalling occasion. The value of fire-proof walls and well-constructed buildings was well illustrated by the successful resistance of the *Times* partition to

the progress of the fire. Had this end of the building been the same in character as the other end there is no knowing where the finish would have been, and it probably would not have been our good fortune to be addressing our readers from our present comfortable quarters, even though they be considered fire-proof. Concerning our esteemed cotemporary, we beg leave to inform our readers that Messrs. Munn & Co., publishers of the *Scientific American* and *Scientific American Supplement*, occupied offices in the burned building. The subscription books and list were protected by a safe and found to be in good condition. The two papers will be sent as usual, and as soon as possible extra numbers will be printed of the *Scientific American* for the past eight or nine years, and of the *Supplement* since its commencement, the plates having been kept in another building. All orders for back numbers will be filed and filled as soon as possible. The offices now occupied by the paper are at 261 Broadway.

PERSONAL.

RALPH R. OSGOOD, of Troy, N. Y., manufacturer of "boom dredges," steam excavators, etc., on Jan. 9, formed a copartnership with JAMES MACNAUGHTON, under the firm name of OSGOOD & MACNAUGHTON. The offices of the firm are at 37 State street, Albany, N. Y.

B. R. MORTON has been unanimously re-elected City Engineer of Newport, O.

THE LATE COL. E. S. PURDY.—The Academy announces the death at Cairo of Col. E. S. Purdy, Pasha of the Egyptian general staff. Col. Purdy was born in the State of New York, and received his scientific training at West Point. At an early age he served under Gen. Stone on the cadastral survey of Sonora and Lower California, and afterward saw service in the war with the Southern States. For several years past he has been one of the most prominent of the American officers under General Stone Pasha, chief of the Egyptian general staff, and has been long engaged in survey work in Upper Egypt. He served with Ismail Eyub Pasha in the Darfur expedition and took a leading part in laying down the map of that province. As lately as May 14 Colonel Purdy exhibited his large map of Darfur at a meeting of the Cairo Geographical Survey, and read a paper on his journey to Dara and Hotra-el-Nahas, giving an account of the inhabitants and resources of Darfur, its fauna and flora, hydrography, etc. Colonel Purdy was only forty-two years of age at the time of his death.—*London Times.*

M. S. LINCOLN, Chief Engineer of the Wabash, St. Louis & Pacific Railroad will have charge of the Bridge and Building departments, including bridges and all structures.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—The Society of Mechanical Engineers of this Institute this week visited some of the great manufacturing establishments of Western Massachusetts and Connecticut, accompanied by Professor Channing Whittaker and his assistant, Mr. William H. Beeching.

A. M. WELLINGTON has resigned the position of Principal Assistant Engineer of the Mexican National Railways to accept that of Assistant General Manager Mexican Central Railway, with headquarters at 5 San Fernando, Mexico.

OBITUARY.

ALEXANDER LYMAN HOLLEY, of world-wide celebrity as a metallurgical and mechanical engineer, died at his residence in Brooklyn on Sunday evening, the 30th ult. He had visited Europe in hopes of finding relief from bodily ailments, but unsuccessfully, and was advised by his medical advisers to return home. His wife and two daughters, comprising his entire family, followed as soon as they could leave Europe and arrived in the Germanic on Sunday but not in time to reach his bedside before death came.

Mr. HOLLEY was born in Lakeville, Conn., in the year 1832, where his father, ex-Gov. A. H. Holley, still resides. He graduated in 1853 from Brown University, and soon afterward entered the Corliss Steam Engine Works. His technical studies were supplemented by a year's practice as a locomotive engineer on the Stonington Railroad. He next worked for a considerable period in a locomotive works in Jersey City. During the period from 1855 to 1860 Mr. Holley published several important works, among the most notable of which were a treatise on "Railway Economy" and "Reports on European Railways." He was assisted in the last-named work by the late Zerah Colburn. At one time Mr. Holley, under the *nom de plume* of "Tubal Cain," contributed a series of letters to the *New York Times*. He crossed to England on the steamship Great Eastern on her first transatlantic voyage, and, becoming acquainted with Brunel and Scott Russell, he thoroughly studied the structure and sea-going qualities of the vessel. He subsequently made the acquaintance of the late Edwin Stevens, of Hoboken, and was engaged as consulting engineer in the construction of the Stevens battery. This work led him to visit England a second time, in 1862, for the purpose of studying the latest improvements in offensive and defensive warfare. The result of his studies was the publication, in 1864, of a treatise on "Ordnance and Armor," which has since been recognized as the standard authority. Through the efforts of Mr. Holley the patents in the United States for the Bessemer process of manufacturing steel were secured in 1864 for an association in this country, and in 1865 the first Bessemer works in the United States were built under his supervision in Troy, N. Y. From that time until his death Mr. Holley continued to be the foremost American expert in that line. The extraordinary progress which the American works have made in this art over those of other countries is conceded to the skill and practical inventive genius of Mr. Holley.

From a paper on "The History of the Bessemer Manufacture in America," read before the American Institute of Mining Engineers at its meeting in Philadelphia, June, 1876, we extract the following: "His mechanical intuition was alive to the possibilities of improvement of the Bessemer process and the result of his thought gave us the present accepted type of American Bessemer plant. He did away with the English deep pit and raised the vessels so as to get working space under them; he substituted top-supported hydraulic cranes for the more expensive counter-weighted English ones, and put three ingot cranes around the pit instead of two, and thereby obtained greater area of power. He changed the location of the vessels as related to the pit and melting-house. He modified the ladle crane, and worked all the cranes and the vessels from a sigle point; he substituted cupolas for reverberatory furnaces, and last, introduced the intermediate or accumulating ladle which is placed on scales, and thus insures accuracy of operation by rendering possible the weighing of each charge of melted iron before pouring it into the converter. These points cover the radical features of his innovations. After building such a plant, he began to meet the difficulties of details in manufacture, among the most serious of which was the short duration of the vessel bottoms, and the time required to cool the vessels to a point at which it was possible for workmen to enter and make new bottoms. After many experiments he introduced the Holley vessel bottom, which has rendered possible, as much as any other one thing, the present immense production. His subsequent invention of the removable lining for the converter, adapted the basic process to American practice. Considering the vast improvements brought about by Mr. Holley's untiring efforts, we cannot but pay a high tribute to his enterprise and activity."

At the time of his death Mr. Holley was receiving a large salary as consulting engineer of the Associated Bessemer Steel Manufacturers in the United States, and having already acquired considerable property, he left his family in comfortable circumstances. Three great societies—the American Society of Civil Engineers, the Institute of Mining Engineers, and the Institute of Mechanical Engineers—have distinguished him with official honors. He was made President of the Institute of Mining Engineers in 1875, and was one of the founders and most enthusiastic supporters of the Institute of Mechanical Engineers. In his numerous papers and addresses before these societies he displayed a high order of literary ability, as well as professional skill and acumen. He was an excellent after-dinner speaker, and of a genial and humorous disposition. He was fond of art, and was a friend of most of the leading artists in this country.

At the May meeting of the Institute of Mining Engineers, held in Pittsburgh in 1879, Mr. Holley was presented with a beautiful gift in silver by his friends and associates in the Bessemer steel interest, as a recognition of his invaluable professional services. His response to Mr. W. P. Shinn's address of presentation will never be forgotten by those who heard it, and few heard it without tears. It concluded as follows: "Among us all who are working hard in our noble profession and keeping the fires of metallurgy aglow, such occasions as this should also kindle a flame of good fellowship and affection which will burn to the end. Burn to the end—perhaps some of us should think of that, who are burning the candle at both ends. Ah! well, may it so happen to us that when at last this vital spark is oxidized, when this combustible has put on incombustion, when this living fire flutters thin and pale at the lips, some kindly hand may turn us down, not underblown—by all means not overblown—some loving hand may turn us down, that we may perhaps be cast in a better mold."

The funeral took place on Wednesday from Plymouth Church, Brooklyn. Rev. Henry Ward Beecher delivered a brief but eloquent address, and large delegations of prominent members of the American Society of Civil Engineers, and the American Institute of Mining Engineers were present, the pall-bearers also being leading men in these associations.

Those only who knew Mr. Holley best can appreciate how severely his loss will be felt.

SEWERAGE OF EUROPEAN CITIES.

From Mr. Rudolph Hering's report, made to the National Board of Health, noticed in ENGINEERING NEWS for last week, we promised some abstracts of statistics from the various cities which were embraced in the field of his observations—and commence with

LONDON.

Population.—Drainage and water-supply district, 4,843,400. Average density, 55.6; varies from 43 to 174 per acre.

Area of Metropolis.—122 square miles = 78,080 acres. Greatest length, 14 miles; greatest width, 8 miles.

Number of Dwellings.—In drainage district, 585,000. Number of inhabitants per house, average, 7.4.

Water Supply.—From rivers Lea, Thames and chalk wells, per day, 145,800,000 gallons; from chalk wells, per day, 9,140,000 gallons; from river Lea, per day, 61,989,000 gallons; from river Thames, per day, 74,614,000 gallons; 145,743,000.

Eighty-one per cent. used for dwellings; 19 per cent. for streets, fountains, etc. Average, 32.7 gallons per head. All river water is filtered.

Mortality.—1840–1849, 25.1; 1850–1859, 24.1; 1860–1869, 24.3; 1870–1879, 23.0.

Meteorological.—Temperature: Thirty years mean annual, 49.4 Fahrenheit; mean monthly maximum, 72.3 Fahrenheit; mean monthly maximum, 32.7 Fahrenheit; maximum seldom above 80 deg., though it has reached 94 deg.; minimum seldom below 15 deg., though it has reached —5 deg.; mean daily range, 16.9; mean monthly range, 36.8 Fahrenheit; frost penetrates soil to a maximum of 2 ft.; rain, annual, from 18 in. to 30 in.; thirty years mean, 24.4 in.; number of rainy days per year, 170; mean humidity, 81. Rain storms, maximum:

	Inches per minute.
1846, August, 3.3 in. fell in 140 minutes; 2 in. in 30 minutes	.067
1852, July, 0.5 in. in 15 minutes	.033
1857, October, 2.92 in. in 36 hours	.0013
1874, May, 0.34 in. in 8 minutes	.043
1874, June, 0.96 in. in 30 minutes	.032
1874, July, 2.23 in. in 84 minutes	.027
1878, June 23, 3 in. (nearly) in 90 minutes	.033
1878, April 10 and 11, 2.84 in. in 19 hours; maximum in 90 minutes.	
1880, July 14, 0.36 in. in 12 minutes	.030

Topographical.—Situate on both banks of the Thames 40 miles above its mouth. Largest area is on the northern bank, where the surface is above floods. Southern bank is low, with districts below ordinary high water, gradually extending to high and hilly grounds near the southern boundary. Average tide in Thames, 18 feet. At Barking and Crossness outfalls mean low water is —7.6; mean high water is +10.72.

Extreme tides:

1874, March 20	high water +16.50
1874, April 18	high water +16.00
1874, Oct. 21	low water —10.00
1875, Nov. 15	high water +16.83
1877, Jan. 2	high water +16.50
1877, Jan. 31	high water +16.00
1877, Oct. 8	high water +16.00

Physical.—Greater part of metropolis is closely built up, especially older portions of the center, north, and south of river. West and northwest contain many open areas, parks and gardens. Total length of streets is 2,600 miles, of which 1,338 miles are paved with macadam and partially granite blocks, 274 miles entirely with granite blocks, 23 miles with asphalt, and 15 miles with wooden blocks.

MANAGEMENT OF PUBLIC WORKS.

They are in charge of a Metropolitan Board of Works, an elected body of 45 members, each serving three years. The metropolis is divided into vestries, larger ones sending one representative and some two, smaller ones combining into districts with one representative. The board is thus formed of representatives from 24 vestries and 15 districts. A chairman is elected from their number. Their duties consist in supervising all main public works, among which is the main drainage system in design, construction and maintenance. The Board levies rates and borrows money for its purpose. All main sewers are both designed and built by the Board. Ordinary sewers in each vestry and district are built by district boards, which have each an engineer and surveyor, with necessary corps of assistants. But all their plans must previously be submitted to the Metropolitan Board for approval. Permanent staff of Metropolitan Board of Public Works, engineer's department: Main office, 1 engineer-in-chief, 2 assistants to chief, 1 principal clerk, 16 engineers and draughtsmen. Flushing staff, 5 inspectors, 8 clerks, 18 gaugers, 107 flushers, 36 sluice and flap keepers, mechanics and laborers. Pumping stations and outfall, 4 superintendents, 126 mechanics and laborers.

DESIGN AND CONSTRUCTION OF SEWERAGE WORKS.

1. *General System and Alignment.*—Combined water-carriage with interception of sewage and slight portion of rain, at several levels, discharging it 10 miles below city into the Thames at outgoing tides. The valley line sewers, mostly old, receive excess of storm-water either direct or from overflows, and discharge by shortest line to the river. The Thames divides the system into two independent parts.

In the north there are three main intercepting sewers: The high, mid and low level, and a few lateral branches, with final outfall at Barking. The high-level sewer begins south of Highgate, extends eastwardly to the valley of Heckney Brook, and crosses Victoria Park to Old Ford. The mid level begins near Harrow Road, passes under Paddington Canal, follows Uxbridge Road, Oxford street, Old street, Victoria Park and joins the high level at Old Ford. These two sewers intersect all sewage that can flow into the Thames by gravity. A branch from the elevated grounds at Piccadilly joins the mid level. From Old Ford to Barking, the two sewers are united in one embankment, built for them on account of the low grounds, and form the northern outfall sewer. At Barking a reservoir of 9½ acres, and 6,700,000 cubic feet capacity, collects and holds all the sewage during incoming tides. The low level sewer runs under the Thames embankment to Blackfriars, thence to Tower Hill and Abbey Mills, where its contents are raised 36 ft. by steam-power, and discharged into the outfall sewer just mentioned. Several branches are connected with the low-level sewer. South of the Thames there is a high-level and a low-level intercepting sewer, with final outfall at Crossness. The high-level is formed of branches skirting the higher grounds and uniting at Deptford, and then continues its course to Crossness at the southern outfall sewer, where the sewage is raised 10 to 30 ft. high into a reservoir, from which it is discharged during outgoing tides. The low-level sewers, one beginning at Putney and the other at Bermondsey, unite at Deptford, where their sewage is pumped 18 ft. into the outfall sewer just mentioned. When crossing these intercepting sewers, the old valley-line sewers are connected with them to take the storm-water overflow and lead it directly into the river. At present several extensive overflow-sewers are being built in addition in various sections. The daily amount of sewage intercepted by the main drainage works is about 10,000,000 cubic ft. north and about 4,000,000 cubic ft. south of the Thames. The united capacity is 63,000,000 cubic ft., including a rainfall of ¼ in. in 24 hours. The system was designed by Sir J. W. Bazalgette.

Shape and Size of Sewers.—London exhibits a greater variety of shape in its sewers than any other city, representing as it does the ideas of several centuries. At present the following forms are used: Circular, for pipe sewers which rarely exceed 18 in. diameter, and for certain intercepting sewers. The egg-shape is common for all brick and concrete sewers, except those for interception and storm-water. The oval form, having a larger invert radius, is used when a comparatively great ordinary flow is to be removed. Other forms, such as flat or slightly curved inverts, or railway tunnel sections, etc., are used for special purposes. For formula used for dimensions see ENGINEERING NEWS, Jan. 28, page 34.

The amount of sewage calculated is one-half of daily amount, assumed at 34 gallons per head, therefore 17 gallons, to flow off in 6 hours.

The smallest sewers used are 9-in. pipes, but generally not less than 12 in. in diameter. The smallest brick or concrete sewers are 2 ft. by 1 ft. 3 in. In the City of London the ordinary sewers are usually of brick, 4 ft. 6 in. by 3 ft. and 4 ft. by 2 ft. 6 in. with a terra-cotta invert block of 10 and 12 in. radius. The northern high-level sewer ranges from 4 ft. diameter to 9 ft. 6 in. by 12 ft.; the mid-level from 4 ft. 6 in. by 3 ft. to 12 ft. by 9 ft. 6 in.; the low-level from 6 ft. 9 in. diameter to 10 ft. 3 in. diameter. The southern high-level sewer ranges from 4 ft. 6 in. diameter to 10 ft. 6 in. diameter. The northern outfall has 3 sewers, each 9 ft. by 9 ft., side by side. The southern outfall is 11½ ft. diameter.

Depth and Grades.—The depth of ordinary sewers below the street surface is from 12 to 15 ft. Cellars and basements are from 5 to 10 ft. deep; and if deeper, sewage must be raised into the sewer by the private parties. When a sewer for purpose of grade is over 16 ft. deep, a second one is built above it to receive house connections. Grades for sewers are usually limited to give a minimum velocity of 18 in. per second. Grades of

Northern high level	1 : 71, then 1 : 376, finally 1 : 1100
Northern mid level	1 : 300 to 1 : 2640
Northern low level	1 : 1760 to 1 : 2640
Northern outfall, 1.2640 (invert at outlet is 18 in. below high water).	
Southern high level	1 : 176 to 1 : 2266
Southern mid level	1 : 100 to 1 : 2266
Southern low level	1 : 1320 to 1 : 2640
Southern outfall	1 : 2640

Junctions, Overflows, Outfalls.—Junctions of sewers are generally made by easy curves, but there is no uniformity in the details. They are generally covered by a funnel arch, and have a tongue between the sewers. The chamber has a ventilator to the surface. Overflows vary in design, and are generally placed at three-fourths of height of sewer. The mouth is wide, to take the water freely, and is then reduced to a circular or egg-shaped channel. Outfalls of main drainage sewers are at Crossness and Barking. At the latter sewage discharges by gravity. It is stored in covered reservoirs of 9½ acres, and discharged only during outgoing tides. At Crossness the sewage is pumped into reservoirs of 6¼ acres, from which it is discharged also during outgoing tides.

Ventilation.—Sewers are ventilated by frequent openings into the streets, generally by special shafts 6 in., 8 in., 10 in., or 12 in. in diameter, terminating in the side of a basin, which is covered by an open grating. Man-holes are also often ventilating. Formerly the furnaces and stacks at pumping-stations were made use of for ventilation, but this is now abandoned, as it checks the draft, and is not efficient except for a short length of sewer.

Man and Flushing Shafts.—Man-holes are mostly built with side entrances, especially in the central portion of the metropolis, having either vertical shafts or steps. When in the street they are circular, and usually 2¼ to 3 ft. in diameter, covered with a grating, partially open and partially with inserted blocks of wood to deaden the noise of passing wheels. When ventilation is required, a small basin to catch the street dirt is placed beside the shaft of the man or lamp-hole, and through this the air passes out. It is about 9 by 18 in., and is covered by an open grate, while the man-hole cover has no openings. Special shafts for flushing are sometimes placed at the upper ends of the pipe-sewers.

Gullies.—The gullies are commonly placed under the gutter, the inlet being covered by a grating 16 by 18 in. hinged. They are generally 4 ft. deep and have almost always a catch-pit and a trap. The pipe leading to the sewer is 6-in. or 9-in. diameter. The trap is formed sometimes by a flag-stone 3 in. thick, let down from the top and sometimes by the outlet pipe itself. The seal is about 12 in. They are not located at the street corners, but in the blocks, generally 200 or 300 ft. apart. Some inlet-basins are of iron 33 by 21 in. and 3 ft. below the grating. There are a few inlets which lead directly into the sewer without trap or basin, by 9-in. terra-cotta pipes.

Pumping-Stations.—London has four large pumping-stations. They are at Deptford and Crossness, on the southern side, and at Pimlico and Abbey Mills, on the northern side of the Thames. The Deptford station is the oldest, having been in use 17 years. The sewage is raised 18 ft. from the southern low-level sewer into the outfall. The inlet is a twin sewer, each 7 ft. in diameter. The ordinary depth of water in them is 4 ft. There are 4 engines, each 125 horse-power. Amount of sewage which can be raised is 13,728 cu. ft. per minute. The Crossness station is situated at the southern outfall. The sewage is raised from 10 to 30 ft. either directly into the Thames or into storage reservoirs, of which there are 4, each holding 6,000,000 gallons, and covering together 6¼ acres. The tide runs out 7 hours. Gates are left open 1 hour before to 4 hours after high tide. There are 4 engines, each 125 horse-power, driving 32 pumps and lifting ordinarily 106,400 gallons per minute. Diameter of pumps, 4½ ft. Four have a stroke of 4 ft. and 4 have a stroke of 2 ft. The works are being extended. Amount of sewage which can be raised per minute is 17,028 cu. ft. The Abbey Mills station is situated on the line of the northern high level, where the sewage from the northern low level is pumped into it 36 ft. high. The diameter of the inlet sewer is 10 ft. 3 in. There are 8 engines, each 142 horse-power, driving 16 double-acting pumps, raising ordinarily 96,000 gallons per minute. The amount of sewage which can be raised per minute is 15,000 cu. ft. The western pumping-station (Pimlico) is the most recently built. Here the sewage from west of Chelsea is raised into the northern low-level sewer. The inlet is 6 ft. 9 in. in diameter with an ordinary depth of sewage of 3 ft. The lift is 17.8 ft. (— 19 to — 1.20 below datum). During heavy storms the sewage is pumped into the Thames. There are 4 engines, each 90 horse-power, with a supplementary engine, 120 horse-power. The engines drive 2 pumps, each of 5 ft. 3½-in. diameter and 4-ft. stroke. Six thousand cubic feet of sewage can be raised per minute. In 1878 the engines at work, representing 2,620 nominal horse-power, consumed about 23,340 tons of coal.

Materials and Construction.—Materials used for sewers are brick, concrete and terra-cotta pipe. Concrete is preferred where not too expensive. Portland cement is used for it in proportions of 1:4 to 6 of Thames ballast (gravel and sand mixed), and allowed to set one week before centers of large sewers (6×4 ft.) are drawn. Concrete sewers many years old presented a perfect condition, with very little adhesion of sewage particles and very little odor.

Before 1846 no sewers were egg-shaped, none were built of vitrified pipe, and none of half bricks.

Statistics.—Ludgate Hill sewer was built before the year 1668; Fleet street sewer was built in 1668; first surveyor for London was appointed in 1768.

Length of sewers:	Miles.
Up to 1855 inclusive	1,148
Up to 1856-1877 inclusive:	
Main drainage	82
District sewers	857
Reconstructed sewers	56
	995
1878 to 1880 inclusive	135
Total length of sewers	2,276

Of which 550 miles are of vitrified pipe.

Intercepting sewers:	
Northern high level, length, miles	7¼
Area drained, square miles	10
Northern midlevel, length, miles	9½
Picadilly branch, miles	2¾
Area drained, square miles	17½
Northern low level, miles	8¼
Hackney branch, length, miles	2½
Isle of Dogs branch, length, miles	1⅞
Area drained, square miles	11
Western extremity of northern low level, length, miles	5¼
Fulham branch, length, miles	1½
Acton branch, length, miles	1⅝
Area drained, square miles	12½
Northern outfall sewer, length, miles	5½
Southern high level, length, miles	5½
Effra branches, length, miles	7¼
Area drained, square miles	20
Southern low level, length, miles	9½
Bermondsey branch, length, miles	2¾
Greenwich and Deptford, length, miles	1⅝
Area drained, square miles	20
Southern outfall sewer, miles	7¼
Area drained, additional, square miles	2

Daily amount of sewage discharged into Thames from both outfalls, 17,600,000 cu. ft. Deptford pumping station was opened ——, 1864. Crossness-pumping station was opened April 4, 1865. Abbey Mills-pumping station was opened July 30, 1868. Western (Pimlico) pumping-station was opened Aug. 5, 1875. Number of gullies in 1878 was 67,491.

Disposal of Sewage.—The metropolitan sewage is discharged into the Thames at Barking and Crossness, 10 miles below the city. It is temporarily stored in reservoirs during incoming tides. Velocity of water in Thames, average 4½ inches per second.

	Reservoirs.		Discharge.	
	Area.	Capacity.	Daily sewage.	Maximum rainfall.
	Acres.	Gals.	Cu. ft.	Cu. ft.
Barking	9½	45,000,000	11,600,000	28,500,000
Crossness	6¼	24,000,000	6,000,000	17,200,000

MAINTENANCE OF SEWERAGE WORKS.

Appliances.—Sewers are cleaned generally by flushing. Old sewers with flat inverts, and new ones when accidental obstructions occur, are entered and cleaned with scrapers and shovels. Pipe-sewers, when they become obstructed, are cleaned with circular brushes drawn through them, or by jointed hooks, which are closed when pushed in, and are forced open by a spring when drawn back. For flushing the pipe-sewers, either flap-valves are used or such as work in a groove, regulated from above to dam the sewage or flushing water. Large sewers have penstocks inserted at necessary intervals. They are generally worked from above, and consist of a heavy door either drawn upward or swinging to one side. The pumping-stations also have penstocks to hold the sewage back temporarily or to regulate the discharge into the river or to the pumps.

The gullies are cleaned regularly and often. The scoops used have a flat or semicircular bottom.

SEWAGE OF LONDON.

In 1878 there were taken out of sewers 723 cubic yards of deposits.

In 1878 there was taken out of street basins 100,050 cubic yards silt.

COST OF SEWERAGE WORK.

Management and Maintenance.—Total cost of maintaining sewerage work under Metropolitan Board, $392,000. The maintenance of all the London sewers cost about 25 cents per head per annum, including pumping, which is about 8 cents per head.

Construction.—Total expended for intercepting and main sewers since consolidation has been $27,500,000. This includes 82 miles of main intercepting drainage and 58 miles of main valley line sewers, making 140 miles. Average cost of main drainage per mile is $280,000; of the main valley line sewers per mile, $65,000.

SAFE AND UNSAFE BRIDGES.

On the 26th ult., before the Society of Arts, Boston, Prof. Geo. L. Vose spoke of the defects in the present method of building and inspecting railroad and highway bridges in the United States. He said that in the year 1881 there were 43 bridge accidents, and that during the nine years ending

with 1881 their number had been 216, an average of 24 per year, not one of which could not have been foreseen by a proper inspection, and prevented. From 1874, when there was 33, there was a steady decrease in the record to 16 in 1880; but the large number of last year has dispelled the hope that a better condition of things was being brought about. In fact, hundreds of bridges on constantly traveled ways are quite as weak as those that have fallen and need but the same combination of circumstances to meet the same fate. Until public opinion demands it, no proper inspection will be made, and the list of casualties from falling bridges will be continued. Unfortunately it is difficult to gain a hearing for the dry details of prevention. In the construction of road bridges provision for a strain of 100 pounds for those of short span to 40 pounds for those of longer span per sq. ft. should be made; in that of railroad bridges the provision should be from 7,000 pounds for those of short span to 2400 pounds for those of longer span per lineal foot. Compliance with these conditions will only make bridges secure for ordinary travel, and it is difficult to obtain them because of the dishonesty of some builders, who construct bridges to sell, and of the ignorance, especially of town and county officers, to whom cheapness, combined with seeming strength is a strong recommendation.

ENGINEERS' SOCIETIES.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

The regular meeting of the society was held on the evening of Feb. 1, Mr. Charles Macdonald occupying the chair until the arrival of President Welch.

The deaths of Moses Lane, member A. S. C. E., at Milwaukee, Jan. 25, and of A. L. Holley, past vice-president of the society, at Brooklyn, Jan. 29, were announced.

The consideration of the paper by Robert E. McMath on "Mean Velocity of Streams Flowing in Natural Channels," which was read, was postponed.

The following named gentlemen were elected members: ENRIQUE BUDGE, Chief Engineer and Director New Government Mole, Valparaiso, Chili; CHESTER B. DAVIS, Chief Engineer Water-Works, Omaha, Neb.; ROBERT GORDON, Chief Engineer Irrawaddy River Embankment Works and Survey, Henzada, British Burmah; GEORGE S. RICE, Civil Engineer, Charleston, Ariz.; THOMAS J. SEELY, Div. Supt. and Asst. Engineer Las Vegas Div. Atchison, Topeka & Santa Fe Railroad, Las Vegas, N. M.; ROMEO PAUL TOMASSEK, Construction Engineer Mexican National Construction Co., New York City, N. Y.

ORGANIZATION OF THE COLORADO INSTITUTE OF ENGINEERS.

A Leadville paper says: "Feeling the lack of any association of engineers and scientists in this section of the country, the civil and mining engineers and metallurgists of Leadville have organized the Colorado Institute of Engineers. The objects of the association are stated to be the exchange of scientific ideas; the discussion of scientific subjects of interest, which are constantly arising in the practice of the professions represented, and the establishment of a library of standard scientific works. Much care and labor have been employed to make the initiatory steps result in the proper basis for a permanent and reliable association, and, after a number of preliminary meetings, the organization has now assumed such shape as to insure a permanent and useful future.

At a meeting held recently, the following officers were elected:

President—Thomas W. Jaycox.
Vice-President—Charles J. Moore.
Secretary and Treasurer—F. L. Sizer.
Directors—F. Guiterman, A. Falkenau, Max Boehmer.
Librarian—Ellery Stowell.

The next meeting of the society will be held on Thursday evening, Feb. 2, at half-past seven o'clock, in room 11, Howell block.

LIVERPOOL ENGINEERING SOCIETY.

The usual fortnightly meeting, being the last of the session, was held on Wednesday evening, the 4th ult., Mr. A. Holt, M. Inst. C. E., President, in the chair. After the election of officers for the ensuing session and some other business, the retiring President in his address gave a paper on "The Proposed Elevated Railway Along the Liverpool Docks." Mr. Holt remarked that Liverpool was a long, one-sided town, the river and docks forming a continuous straight boundary on the west side, along which personal transit had always been very difficult. The dock omnibuses, through no fault of their own, are very slow and uncomfortable; in fact it is virtually impossible to have a quick and comfortable omnibus service along the Liverpool docks. He had entertained for many years crude ideas of a high level railway to obviate these disadvantages. The works of the Mersey Docks and Harbor Board, under the Act of 1873, being at the extremities, only made matters worse; in fact, Liverpool was fast becoming a two ended town, with all offices, etc., in the center, and the ships at each end, a very disadvantageous condition of things. His attention had been attracted to the New York structure, of which he gave a description. The capital embarked in this undertaking was excessive, and had the natural result—high fares; but it was a great success on the whole, and very considerable increase was proposed. He drew attention to the insecure appearance of the New York structure and doubted if such would be acceptable to the Liverpool public, entertaining the opinion that on the whole a safer appearance would be desirable. In deciding the class of structure to be adopted in Liverpool the much smaller traffic, as compared with New York, should be taken into account. On these and similar grounds he advocated a single line system as sufficient, and the Act of 1878 was based thereon. He described the proposed structure, and touched on the question of having the "trough" or the "American" system of girder, describing both. He also showed the mode of working stations, and economy being necessary, had arranged for the minimum number of employés. The carrying powers of the line, its speed and check on money receipts were alluded to, and estimates of cost and of working expenses were given. The reason why the proposal for a single line has been abandoned was explained, it turned on the question of safety in working the single line station, to which the Board of Trade officer had objected. Mr. Holt pointed out that on certain conditions the single line system was preferable to double line on the ground of safety, and explained, by comparison, the real advantages and disadvantages of single and double line system. His opinion was that though the double system may be, under the circumstances, obligatory, it is evidently an excessive provision for the wants of Liverpool. So strong has been the set of opinion in favor of double line, that it led to the abandonment of single line scheme, and the promotion of a new Act of Parliament for next session. The author then gave a description of the proposed work, explained how the Stanley dock was to be bridged, and the Lancashire & Yorkshire Coal Railway got under, and how headway was provided under the line to take large pieces of machinery to the dock. He concluded with remarks on the general improvement to be expected in Liverpool, and in the method of carrying on the shipping business as the result of the railway when carried out, and touched on the alternative question of communication by tunnel along the docks, which he did not consider so suitable a means of communication as the proposed railway. A vote of thanks to Mr. Holt for his very interesting paper and for the manner in which he had presided over the meetings during the year was carried by acclamation. The President then vacated the chair and Mr. F. Salmon, M. I. and S. Inst., the elected president for the ensuing session, took the chair and addressed the meeting. He announced that the next meeting of the Society would take place Jan. 18, 1882, when a paper would be read by Mr. H. F. Bellamy, on the Plymouth Corporation Water-Works. Votes of thanks to the officers of the Society for their services during the past session concluded the business.

The first meeting of the eighth session of this society was held on the 18th ult., at the Royal Institution, Colquitt street, the President, Mr. F. Salmon, M. I. & S. Institution, in the chair. After the usual business, Mr. H. F. Bellamy read a paper on "The Plymouth Corporation Water-Works."

The author, having called attention to the fact that the antiquity of the present supply of water to the town of Plymouth rendered the subject more than usually interesting, pointed out, on a bird's-eye view of the town, the geographical position of the district supplied with water by the Plymouth Corporation, proceeded to review in detail the history of the present source of supply—passing around photographs of maps of the town made during the reigns of Henry VIII. and Elizabeth, the originals of which are in the possession of the Marquis of Salisbury, in the Hatfield Library. He then showed that prior to A.D. 1590, the chief source of supply was from wells in the town, and that the corporation, finding this supply inadequate, obtained an Act of Parliament—a brief extract of which was given, and which continues to the present day—to introduce a supply from the River Meavy, by means of an open channel or "leat."

By quoting extracts from ancient corporate account books, and exhibiting a copy of the original plan for the construction of the "leat," he showed the cost and mode of carrying out the work, and the system of distribution, and charges made after the introduction of the water.

In describing the present condition of the works, he stated that the original "leat," in a repaired condition amounting almost to reconstruction, was still used for twelve miles of its course, discharging the stream into a service reservoir three miles from the town, from which the water is conveyed by two lines of pipes, 12-in. and 24-in., to the distributing reservoirs two and three miles distant, thereby cutting off seven miles of the old course. He described, by a working drawing, the settling tanks, through which the water passes before entering the reservoirs.

With reference to proposed improvements, he stated that the supply still being inadequate, a storage reservoir of about 350 million gallons capacity is to be constructed within the water-shed of the River Meavey above the Head Weir. The resources of this water-shed he showed to be very great. The pipe line is to be extended about five miles to Roborough Down, and a series of settling tanks and an intake reservoir constructed there.

In conclusion, he gave details of consumption and quantity of water available, the rules and regulations, rates for domestic and other supplies, and analysis of water.

After the paper, which was illustrated by plans, photographs and drawings, had been read, a discussion took place, and a vote of thanks to Mr. Bellamy for his interesting paper was given. The President announced that the next meeting of the Society would be held on the 1st of February, when Mr. Wm. Goldshaw would read a paper on Municipal Control of Streets and Buildings.

THE IRON TRADE.

(Prepared expressly for ENGINEERING NEWS.)

Railroad companies, construction companies and projectors of numerous enterprises requiring vast quantities of iron and steel have about completed their estimates and formulated their plans for 1882. There has been very little to interfere with this preparatory work. Confidence in the permanence of the industrial prosperity has not been weakened by unusual or unexpected occurrences. Capital is abundant, immigration continues and prospective possibilities are favorable. No unfavorable legislation is threatened. The volume of sound currency seems sufficient for all probable requirements. The warnings which have been sounded through the press were based, not on specific evidence, but on general probabilities as to over-investment and over-production, and over-doing in general. Producing and transportation interests are resolved that they shall not be found guilty of short-sightedness in the expansion of facilities to meet the rushing requirement of consumers and exchangers. The closest investigation and inquiry fails to unearth any decline in activity in any of the great avenues of activity. Railroad construction is being as vigorously prosecuted as weather and supplies will admit. Differences of opinion exist as to the probable amount of railroad building that will be accomplished this year, but thus far no facts are at hand to modify recent utterances on this subject. For several weeks demand has seemed to fall off in American mills, but the falling off is due to their oversold condition and not to lack of demand. In fact, these mills could accept business now or at any time, sufficient in volume to carry them far into 1883. This might be done if steel rail manufacturers had control of the sources of raw material, but as they are obliged to come into the open market and bid against the world for material to fill contracts they are obliged to limit engagements to their probable ability to cover them. In addition to this the activity in railroad construction at home and abroad has not reached a climax, and prices exhibit generally an upward tendency. Recently, however, steel rails have declined, and offerings are made at mill of $55, foreign at tide $56@$57, while Bessemer pig has sustained a sharp decline, under which an active demand has sprung up. These facts justify conclusions and inferences presented weeks ago that railway material would decline eventually, and that the decline would stimulate enterprises and engineering work all over the country. Within two weeks inquiries have been made at the leading iron centers for large supplies of iron and steel for spring, summer and fall delivery. Bridge work, pipe work, and railway construction requirements are the leading items. The present indications are that a very large amount of work of this character will be placed.

There have been rumors of fluctuating values, of sharp advances, of heavy importations, but the bulk of these rumors have no foundation. The bridge works East and West are overcrowded, and will soon have the opportunity presented of extending engagements. The plate and tank mills have been refusing summer contracts, and are crowded with high-priced contracts between 3½c. for common to 5c. for flange iron. Customers are soliciting an indefinite continuance of engage-

ments. The recent course of pig-iron has created more or less uncertainty in the minds of manufacturers as to what is really best to do. Contractors desire to know fixed prices. Crude iron is $2 per ton higher than when existing contract work was taken. This is a serious matter. A decline of $2 is not an impossibility if a score or two cargoes of English iron were to be unloaded here. Nor is it sure any harm would follow because of the unusual foreign activity. Still there is some uncertainty, and it is the only unfavorable feature in the entire situation. The general tendency is to book orders subject to market fluctuations, but this method, while checking the upward tendency, has its defects. Production meanwhile is steadily increasing at furnaces and mills, while consumption is following closely on its heels. The great enterprises are not taking alarm, and it is not probable that imaginary difficulties will be permitted to interfere with the carrying out of the large number of projected works, larger than ever engaged the skill and energy and capital of the nation.

FACTORS OF SAFETY.*

BY ALBERT F. HILL, C. E.

Recent structural failures of bridges, marine engines, boilers, etc., followed by ghastly reports of coroners' inquests in the daily press, and by more or less scientific discussions as to their causes in the technical journals, have lately brought the term "factor of safety" prominently before the public.

In the present general acceptation of the term the factor of safety expresses the ratio between calculated maximum strain and ultimate or breaking strength of the material employed in a given structure. For instance, wrought iron is conventionally assumed to have an ultimate tensile strength of 50,000 pounds per square inch; if the greatest calculated stress upon it, in a given structure, does not exceed 10,000 pounds per square inch of its effective section, the iron is said to be used with a factor of safety of five, or in common parlance, to be "five times as strong as the greatest load that can come upon it." That this conclusion is an absolute fallacy, is well known to modern engineers, but its pernicious influence is hardly fully appreciated as yet. It gives not only a very undesirable latitude to incompetent designers, but also encourages unscrupulous manufacturers to take large risks, especially under the spur of close competition; it misleads that class of laymen who, either by their official position or as capitalists, are interested in the carrying out of public works; and finally, it is to-day the fruitful source of disasters, brought about by unreasonable—one might almost be tempted to say brutal—tests of structures. Take, for example, our so-called "hydraulic test" of steam boilers. A perfectly new —or, for that matter, old—boiler pumped full of cold water under a pressure far in excess of any steam pressure it will ever have to bear! Is there any analogy between the test and the work required of the structure? And when this brilliant experiment is finished, can anybody tell the possible —and probable—amount of injury done to a previously good and serviceable boiler? All we know is, that "recently inspected" boilers do most unaccountably burst. These tests would never be carried to the excess to which they are but for the fallacious idea of our margins of safety. In the same unreasonable manner are bridges often overtested; loads and shocks are applied to them far in excess of any which the traffic ever can or will bring upon them, and this before an opportunity was given the different parts to assume their working bearings. These excessive strains, while they do not cause immediate failure, do cause, in many cases, permanent and not easily discoverable injury, which only becomes apparent through some "unaccountable" failure.

The responsibility for the fallacious conceptions of our margins of safety, or safety factors, rests mainly upon the inexact but hitherto accepted method of ascertaining the ultimate or breaking strength of materials. This method—employed by the earliest investigators—consisted in taking pieces of constructive materials of any square unit of section and breaking them by gradually increasing loads. Bars of iron, steel, wood, copper, etc., of given lengths and, let us say, of exactly 1 sq. in. of section, were thus broken, and the average of the loads which caused rupture in the bars of the same material was then fixed upon as the ultimate or breaking strength of that material. It is self-evident that these results do not represent the ultimate or breaking strength of the material, but simply the one load which at a single application will produce rupture. A somewhat lesser load, applied several times in succession, would also have produced rupture, a fact of which everybody is cognizant and of which we avail ourselves instinctively when endeavoring to break a string or a stick, etc. If not successful in the first application or [illegible] lar force, the attempt is repeated until fract[illegible] effected. The muscular force in these successive attempts not being increased, and the first force applied not being equal to the breaking load, shows that a lesser load by sufficient repetition has at least produced rupture. This opens at once the question, what then is the ultimate strength of materials?

Modern investigations and experiments, conducted with great care, improved testing machines, and covering a wider field of observations than was formerly deemed necessary, have established the following facts, viz.:

1. Successive increments of load put upon bars of any constructive material will produce elongation of the bar.

2. These elongations will be proportionate to the loads, and uniform for uniform increments of load up to a certain limit.

3. Within this limit of load the bar, when released from its load, will return to its original length.

4. When this limit is once exceeded and the bar then released, it will not fully recover; a permanent elongation, called "set," will be found to have taken place.

5. After permanent set has taken place, the elongations become irregular, greater and greater for equal successive increments of load, and every successive load will also increase the amount of permanent set, until rupture finally takes place.

6. *Any load in excess of the one producing permanent set will ultimately produce rupture, if sufficiently often repeated.* The number of repetitions necessary to produce rupture decrease in proportion to the increase of load, until finally a load is reached, the single application of which produces rupture.*

The point at which permanent set takes place has been designated as the limit of elasticity of the material; but, in fact, the limit of elasticity is not reached at that point at all, but lies invariably very near the breaking point, for after permanent set has taken place successive increments of loads, if removed, will still show partial recovery of length in the bar, though with a constantly increasing set, until at last a point is reached where no recovery of length takes place—now elasticity is destroyed or its limit reached—and from that point on a comparatively very small force suffices to pull the bar apart. The permanent set is therefore indicative of the point of permanent injury to the material, rather than of its limit of elasticity. Having thus shown that what is at present called the breaking strength is as arbitrarily chosen and as meaningless a quantity as the zero point of a Fahrenheit thermometer, and, therefore, almost worthless when used as the standard to which factors of safety are to be referred, and having further called attention to the fact that the term limit of elasticity is rather a misnomer, it is now proposed to inquire what influence would be exercised upon the prevalent ideas of margins of safety, and consequent methods of proportioning structures, by a proper nomenclature expressive of the available strength of material to resist stress.

Remembering that any load in excess of the one producing permanent set will, by sufficient repetitions, produce failure, it would seem pretty clearly indicated that the working usefulness of the material is limited by the load at which set takes place. This being the case, we may properly say that *the load under which permanent set first takes place is the equivalent of the ultimate working or safe strength of the material.* This safe strength differs in ratio to the so-called breaking strength in different materials, varying in amount from 30 per cent. to 60 per cent. of the latter. For example, in wrought iron it will be found that permanent set takes place at from 25,000 to 28,000 pounds per square inch of section, thus reducing the supposed safety factor about one-half. It is true that this is ample for most cases, and even more than is necessary in some. What, then, may be asked, is gained by the proposed change? If nothing else, the true margin of safety is substituted for a false one, and with this, in many cases perhaps, the temptation removed to speculate, as it were, upon fictitious assets. But that this is not the only gain is easy of demonstration. A full appreciation of the true safe strength of the material cannot fail to call out a closer inquiry into the proper functions of safety factors—*i. e.*, what they are intended to cover, and what they never meant to cover.

There is no denying the fact that even at the present day there is in many minds a vague idea that safety factors are a sort of mechanical charity intended to cover a multitude of sins, both of omission and commission. In this may be found the reason for the deliberate overloading of many [illegible] designed years ago for the passage of locoand rolling stock such as were then in use; since then the concentrated loads on drivers, weight of rolling stock and traffic have nearly doubled, yet such bridges are left in use to-day without any attempt at properly strengthening them for these increased loads. Nothing but misconception of the true margin of safety is chargeable with this neglect. For the same reason, tedious and sometimes difficult calculations of details and connections are often neglected in the first place by designers; "common practice" is blindly followed, without investigation as to whether it is properly applicable to the case in point, and any qualms of conscience are stilled with the answer, "Our factor of safety is sufficient." Manufacturers will use material not in accordance with specifications, and console themselves, and the inspector also, with the assurance that the safety factor is meant to cover just such deficiencies. Add to this the necessarily more or less imperfect workmanship—for structures like bridges, engines, boilers, etc., cannot be put together with the nicety to be found in an astronomical instrument—and it will be seen how easy it is to overburden the safe strength. Call it dealing in truisms to repeat here that the weakest point of a structure is the exponent of its strength, yet it will be safe to assert that this old maxim has not been quite as often uttered as it has been overlooked and disregarded.

If full and proper weight is given to the fact that the point of permanent set is the limit of the working capacity of the material, no matter how much more force may be required to produce rupture after that point is passed, and also that within that limit lies perfect safety, it cannot but lead to more rational methods of dimensioning than are at present generally adopted. With it will come a better understanding of the difference in the effects of live and dead loads, and consequently, methods of dimensioning of the different parts of a structure in accordance not only with the amount of combined dead and live load, but also in accordance with the ratio between the dead and live loads they are meant to resist. This in turn must lead to the avoidance of superfluous weight—always detrimental to any structure—a more carefulconcentration of material along the line of strains, the better strengthening of details—especially connections—proper modification of shapes and dimensions in those parts particularly subject to shock, and last, but not least a proper taking into account of the facilities of the manufacturer, which determine in a large measure the character of workmanship, and ought to influence the adoption of a lesser or greater margin of safety.

Our representative bridge works and machine shops have, more or less, for some time past adopted improved methods of proportioning and dimensioning, and are constantly experimenting and improving, but it must, on the other hand, be admitted that their number is limited and the amount of work turned out by them small in comparison to the immense production of structural work going on all over this country.

Factors of safety will always be needed and therefore will always be provided in construction. But because we cannot, for instance, always provide against the phenomenal effects of hurricanes and tornadoes this is no reason why perfectly calculable wind pressures should be left out of consideration and be vaguely saddled upon the safety factor. Imperfections of material, however carefully selected, inspected and manufactured, will never be fully obviated; but this is no reason why material known to be flawed should ever be permitted to enter a structure on the plea that the factor of safety will cover the deficiency. Perfect workmanship is, of course, out of the question, but this is no reason for relying upon the safety factor to make up for positive carelessness and negligence in the shop. Let us hope that the near future will eradicate from all our structures bad proportions, bad connections, bad workmanship, in short, all that is ascribable to "Trust in Providence and—a large factor of safety."

* From *Mechanics*, Jan. 28

* These phenomena of tensile strength hold good also in a general way in reference to compressive, transverse, shearing and torsional resistance. The foregoing observations are borne out by the experiments of Wohler, Spangenberg, Barba, Kirkaldy, Thurston, etc., and were verified by over 2,000 tests made by the writer on iron, steel and wood, and comprising specimen tests as well as tests on full-sized bridge members.

CONTRACTORS AND ARCHITECTS.—The demands of the contractors for certain changes in the printed agreements which are furnished by architects for signature, previous to the commencement of work, have not as yet been agreed to. In fact, it is doubtful if the architects will agree to the conditions sought to be imposed at all. One ofthem is that in case of dispute for extra work arbitrators be appointed—one by the contractor, one by the architect and another by the proprietor of the building. Thus the architect's claim would cause a great deal of useless labor and annoyance. They claim that in all the leading cities the matter of extra pay is left in the hands of the architect, and they do not see any necessity for having an exception made in the case of London. In the meantime the contractors have had a lengthy set of rules drawn up by W. R. Meredith, Q. C., and submitted to the architects. It is stated they will not tender for any work offered by those architects who refuse to agree to the terms laid down bythem.—*London (Ont.) Gazette Jan. 30.*